E3B The Elements of Bioremediation, Biomanufacturing & Bioenergy Metals in Biology

Durham University · University of Kent · Manchester 1824 · Biotechnology and Biological Sciences Research Council

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The impact of biological and thermal pre-treatment of sewage sludge on trace element availability for anaerobic digestion

"This project has played a pivotal role in gaining deeper understanding of the dynamics between pre-treatment and trace-element requirements; hence taking advantage of their synergy to increase energy recovery."

PROJECT AIMS: Anaerobic digestion is extensively used to stabilise and recover energy from municipal sludge. But it is unclear how sludge pre-treatments affect the presence of trace elements (metals) and ligand formation, which are involved in in the biological degradation process. In this project, we investigated the influence of thermal and biological pre-treatments on trace element speciation and bioavailability. Such pre-treatments are important cofactors that help maintain process stability and optimise the recovery of renewable energy from municipal sludge.

OUTCOMES & NEXT STEPS:

- A presentation at the 2022 ECOSTP conference in Girona, Spain.
- Further collaboration with Anglian Water on the optimisation of advanced anaerobic digesters is underway.
- A paper is being prepared.
- The results have informed trials on continuous advanced anaerobic digesters.
- It is envisaged that the results of this project will improve advanced anaerobic digestion by augmenting existing pre-treatment technologies with strategic trace-metals supplementation.

RESULTS:

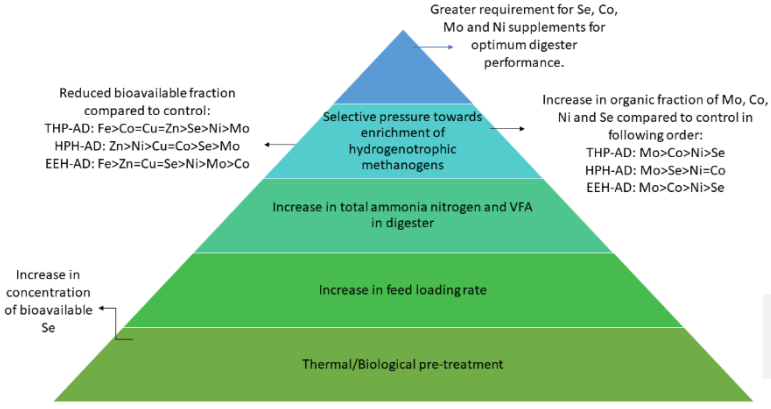
The project investigated the impact that thermal and biological pre-treatment have on the need and availability of trace elements (metals) known to act as catalysts for anaerobic digestion, which support renewable energy generation. These included iron (Fe), zinc (Zn), copper (Cu), nickel (Ni), selenium (Se) and molybdenum (Mo).

Both pre-treatments resulted in increased total ammonia nitrogen (TAN) and volatile fatty acid (VFAs) concentrations in digesters, which are known to increase the level of trace elements needed to sustain stable anaerobic digestion. This increased need is linked to a tendency to shift the predominant metabolic pathway for biogas formation to hydrogenotrophic methanogenesis (mediated by *Methanosarcina* sp.), which has been reported to be more stable with supplementation of elements like Fe, Co, Ni and Se.

This project then investigated the level of trace elements bioavailable for the anaerobic digesters. We evidenced that both pre-treatment types increased the bioavailable fraction of Se in sewage sludge, with increases of 19 to 27% over non-pretreated sludges but did not translate into a net increase in bioavailable fraction in the digester, possibly due to their reabsorption into more recalcitrant fractions.

The study therefore establishes a greater need for trace element supplementation for biologically or thermally pre-treated anaerobic digesters when compared to conventional digesters (without pre-treatments). These results inform on how we can optimize advanced anaerobic digesters through trace element supplementation to increase renewable energy generation from sludge, hence advancing the technology readiness level (TRL) of the research.

Change in technology readiness level: 2 to 4.



The impact of pre-treatment on trace element speciation and bioavailability in the feed and digester.